Manitoba
Environment
and Workplace
Safety and Health

EMISSION INVENTORY OF ATMOSPHERIC SULPHUR DIOXIDE AND NITROGEN DIOXIDE POLLUTANTS WITHIN THE PROVINCE OF MANITOBA FOR 1981 and 1982

By
A. M. Campbell, Environmental Officer
Air Standards and Studies Section
Environmental Manageme Services Branch
Environmental Manag t Division

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ABSTRACT

Atmospheric emissions of sulphur dioxide and nitrogen dioxide from various sources in the Province of Manitoba have been estimated for the years 1981 and 1982. Included in this inventory are major industrial sources, power generating sources, transportation sources, general heating sources, and natural sources.In addition, regulated levels of these pollutants have been reported.

Total emissions of sulphur dioxide for 1981 and 1982 were 525,959 tonnes and 468,604 tonnes respectively. Anthropogenic sources accounted for 423,835 tonnes and 366,480 tonnes in 1981 and 1982 respectively, while natural sources (as "equivalent SO_2") accounted for 102,124 tonnes in each year. Of the anthropogenic sources, the largest contributor by far was from two major metal smelters located near the mid latitude line of the province. Together, these two sources generated roughly 95% of the total anthropogenic emissions of sulphur dioxide.

Total emissions of nitrogen dioxide for 1981 and 1982 were 588,156 tonnes and 547,225 tonnes respectively. Anthropogenic sources accounted for 73,813 tonnes and 72,194 tonnes in 1981 and 1982 respectively. Of the anthropogenic sources, the most significant source was from the transportation sector which accounted for roughly 80-90% of the anthropogenic emissions. Of the total nitrogen dioxide emissions however, anthropogenic sources account for only 10-15% of the total with the remainder being due to natural sources (calculated as "equivalent NO_2").

The emission estimates were based on currently accepted methods including emission factors published by the Environment Canada and/or the United States Environmental Protection Agency. When available, emission calculations were based on stack sampling surveys which provide source specific data or on monthly mass balance reports provided by particular companies.

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Table 1: LIST OF ABBREVIATIONS

ADFM	:- actual dry cubic feet per minute
AP-42	:- see References (Environmental Protection Agency 1977)
Btu	:- British Thermal Unit
cu. ft.	:- cubic feet
imp. gal.	:- imperial gallon
kg	:- kilogram
L	:- litre
MADTP	:- metric air dried tonne of production
MCF	:- thousands of cubic feet
Mg	:- megagram (equal to one tonne)
m^3	:- one cubic meter
NO_2	:- nitrogen dioxide (or oxides of nitrogen as nitrogen dioxide)
SO_2	:- sulphur dioxide (or oxides of sulphur as sulphur dioxide)
t	:- metric tonne

Table 2: SUMMARY OF SO_2 and NO_2 EMISSIONS (Tonnes per year)

ANTHROPOGENIC SOURCES	1981 SO_2	1981 NO_2	1982 SO_2	1982 NO_2
Primary Copper and Zinc and Nickel Production				
Process	(402,896)	(negl.)	(346,135)	(negl.)
Fuel	(345)	-	(307)	-
Total	403,241	negl.	346,442	negl.
Petroleum Refining				
Total	5,341	294	4,427	281
Kraft Pulping				
Process	(65)	(negl.)	(55)	(negl.)
Fuel	(1,409)	(311)	(1,111)	(265)
Total	1,474	311	1,166	265
Sulphite Pulping				
Process	(245)	(negl.)	(208)	(negl.)
Fuel	(867)	(337)	(794)	(318)
Total	1,112	337	1,002	318
Sulphuric Acid Production				
Total	507	negl.	507	negl.
Cement Manufacturing				
Process	(negl.)	(negl.)	(negl.)	(negl.)
Fuel	(63)	(868)	(68)	(528)
Total	63	868	68	528
Clay Manufacturing				
Process	(176)	(negl.)	(146)	(negl.)
Fuel	(negl.)	(8)	(negl.)	(7)
Total	176	8	146	7
Lime Manufacturing				
Process	(negl.)	(negl.)	(negl.)	(negl.)
Fuel	(7)	(125)	(6)	(102)
Total	7	125	6	102
Secondary Lead Production				
Process	(701)	(negl.)	(424)	(negl.)
Fuel	-	-	-	-
Total	701	negl.	424	negl.
Fertilizer Manufacturing				
Process	(268)	(516)	(342)	(308)
Fuel	-	-	-	-
Total	268	516	342	308

ANTHROPOGENIC SOURCES (cont'd)	1981 SO_2	1981 NO_2	1982 SO_2	1982 NO_2
Power Generation by Utilities Total	3,305	1,315	2,177	863
Industrial Fuel Combustion Total	731	1,242	1,941	1,547
Commercial Fuel Combustion Total	1,371	2,342	2,365	3,679
Residential Fuel Combustion Total	829	1,124	886	1,366
Fuelwood Combustion Total	negl.	168	negl.	138
Internal Combustion Engines (Road Use) Total	786	28,800	793	27,600
Railroads Total	1,330	11,471	1,194	10,300
Marine Engines Total	8	9	9	9
Aircraft (1978) Total	164	2,967	164	2,967
Internal Combustion Engines (Off-Road Use) Total	160	3,430	160	3,430
Diesel Powered Engines Total	2,230	18,440	2,230	18,440
Solid Waste Incineration Total	31	46	31	46
ANTHROPOGENIC SOURCES TOTAL	423,835	73,813	366,480	72,194

NATURAL SOURCES	1981 SO_2	1981 NO_2	1982 SO_2	1982 NO_2
*(Soils, Lakes, Marine, Lightning) Total	102,124	473,439	102,124	473,439
Forest Fires Total	negl.	40,904	negl.	1,592
NATURAL SOURCES TOTAL	102,124	514,343	102,124	475,031
TOTAL ALL SOURCES	525,959	588,156	468,604	547,225

* Calculated as SO_2 and NO_2. SO_2 result assumes conversion of reduced sulphur compounds to sulphates (Environment Canada 1980). NO_2 result includes only N_2O and NO_x as reported and excludes NH_3 and amines (Environment Canada 1981).

Note: throughout this report
"-" means "not calculated here but included elsewhere"
"negl." means negligible

1. INTRODUCTION

1.1 SCOPE

This report identifies and quantifies the major sources of emissions of sulphur oxides and nitrogen oxides to the atmosphere in Manitoba for the years 1981 and 1982. Liaison with Environment Canada in the development of this report was undertaken in order to maintain a consistency of approach. Results are presented in terms of equivalent sulphur dioxide and nitrogen dioxide and all discussion is in terms of these pollutants rather than "oxides of sulphur" and "oxides of nitrogen".

This report is published without prejudice to other reports which may yield somewhat different results because of differences of approach. Neither are the results in this report held to be definitive as more and better information may allow improved accuracy in the emission estimates to be made.

1.2 METHODOLOGY

1.2.1 Emission Factors

Air pollution emissions are generally calculated by using emission factors which allow some readily available annual parameter such as tonnes of raw material, tonnes of production, or hours of production to be converted into an estimate of annual emissions. These factors have been obtained through a variety of methods and may be thought of as an 'average' rate of emission for a particular process or situation. Many emission factors used in this report were

published by the United States Environmental Protection Agency in a report entitled "Compilation of Air Pollutant Emission Factors" (Environmental Protection Agency 1977). This reference is often cited simply as AP-42. Often, factors developed specifically for Canadian conditions by the Air Pollution Control Directorate of Environment Canada were used (Environment Canada 1983a).

1.2.2 Mass Balance Reports

The method of mass balance uses information relating to the difference between measured quantities of an element in the input materials and measured quantities in the output materials. This difference is assumed to have been emitted as a pollutant. In a number of cases, mass balance reports were available from the company on a monthly basis. This method was used primarily for the largest sources of industrial emissions namely the primary nickel, copper and zinc producers, and petroleum refining industry.

1.2.3 Industry Specific Emission Factors (Stack Sampling Surveys)

In a number of industries, testing had been undertaken for stack emissions of sulphur dioxide and nitrogen dioxide and industry specific emission factors were developed. Several of these differed significantly from published emission factor data but were felt to more accurately reflect emissions from that particular source.

1.2.4 Multiple Calculations

In some instances more than one emission estimate was possible. Usually this entailed an emission factor calculation and stack sampling results or mass balance results. In these cases, a judicious choice was made between the various calculations with a tendancy to use the higher emission rate in doubtful cases.

2. INDUSTRIAL EMISSIONS

2.1 PRIMARY COPPER AND ZINC, AND NICKEL PRODUCTION

Sulphide ores containing the above metals are first concentrated by a non polluting process and are further purified by roasting, smelting, converting and fire-refining. The pyrometallurgical process drives off the sulphur in the ore as sulphur dioxide. Both of the Manitoba non-ferrous smelters currently report SO_2 emissions on a monthly basis using a mass balance method and these serve as the source of estimates of annual emissions cited in this report. The sulphur dioxide emissions from coal used in copper and zinc production have been included. Nitrogen dioxide emissions were not considered to be significant.

Table : Annual Emissions: Primary Copper and Nickel Production (tonnes)

		SO_2	NO_2
Nickel Production	1981	153,953	negl.
	1982	127,250	negl.
Copper and Zinc Production	1981	249,288	negl.
	1982	219,192	negl.
Total	1981	403,241	negl.
	1982	346,442	negl.

2.2 PETROLEUM REFINING

One refinery was operational in Manitoba in 1981 and 1982. The plant has since ceased operations (September, 1983). Sulphur dioxide emissions were calculated from twice weekly mass balance tests on all sources of SO_2. The annual emission rate was calculated by averaging these tests and multiplying by the number of production days in the year. The NO_2 sources at the refinery were from the gas process heaters, oil process heaters and the catalytic cracking unit. Factors used for these sources were taken from Environment Canada.

Table : Annual Emissions: Petroleum Refining. (tonnes)

Year	SO_2	NO_2
1981	5,341	294
1982	4,427	281

2.3 SULPHATE (KRAFT) PULPING

One kraft mill was in operation in Manitoba in 1981 and 1982. Two sources of emissions were included in estimates of emissions from this category. First, are process emissions related to chemical treatment of the pulp and second are fuel consumption emissions related to type and quantities of fuel used to run the processes and heat the plant. Emissions of SO_2 from the process

were measured in 1982 by in-plant testing and were found to be .512 kg/MADTP which is considerably less than the average for the industry (Benjamin 1979). Sulphur dioxide from fuel consumption was based on the sulphur content of the Bunker fuel (heavy heating oil) consumed (Note: the long term average of the particular bunker was obtained from the supplying refinery) and from the emission factor supplied for the burning of hog fuel (a mixture of bark and waste wood) (Environmental Protection Agency 1977). The hog fuel factor was pro-rated in accordance with the composition of bark and waste wood which was stated to be 90% and 10% respectively. The NO_2 emissions originating from the burning of Bunker 'C' and hog fuel were included based on factors from AP-42 (Environmental Protection Agency 1977).

Table : Annual Emissions: Sulphate Pulping (tonnes)

Year	SO_2	NO_2
1981	1,474	311
1982	1,166	265

2.4 SULPHITE PULPING

One plant in this category was operating in Manitoba during 1981 and 1982. As in the kraft pulping process, two sources of emissions have been included from this category. Process SO_2 emissions have been measured and, while much lower than the industry average, have been accepted at the measured value of 1.56 kg/MADTP. The power boilers used at this industry burn coal and hog fuel. The

coal is primarily Saskatchewan lignite and a sulphur content of 0.5% by weight was used. Factors for SO_2 from hog fuel combustion were taken from AP-42 and pro-rated to the amount of wood bark (90%) and waste wood (10%). Nitrogen dioxide emission factors for coal burners of 50,000 lb steam per hour capacity and for hog fuel combustion were taken from AP-42.

Table : Annual Emission: Sulphite Pulping (tonnes)

Year	SO_2	NO_2
1981	1,112	337
1982	1,002	318

2.5 SULPHURIC ACID PRODUCTION

Sulphuric acid production in Manitoba is derived from one plant using the elemental sulphur process. The plant capacity is 150,000 tonnes annually with actual production in recent years being a high proportion of this capacity. Stack sampling tests conducted in 1979 were considered to be representative of the conditions in 1981 and 1982. Sulphuric acid mist is emitted along with the SO_2 and was added into the emission factor as "SO_2 equivalent" (i.e. the quantity was pro-rated according to the ratio of the molecular weights). The emission factor determined by stack sampling was significantly less than that suggested in AP-42. This may be partially accounted for because this particular plant uses extra layers of catalytic convertors. Exact annual production figures were

not volunteered by the plant but approximate figures were given and were stated to be similar in 1981 and 1982 hence the identical emissions for these years. Emissions of NO_2 were assumed to be negligible.

Table : Annual Emissions: Sulphuric Acid Production

Year	SO_2	NO_2
1981	507	negl.
1982	507	negl.

2.6 CEMENT MANUFACTURING

Two cement manufacturers were operating in Manitoba in 1981 and 1982. Natural gas was the main fuel source accounting for more than 75% of production. This fuel was supplemented by waste oil and Bunker "C", a heavy heating oil. Because materials are heated by direct contact with the heating fuel gases, a good deal of the sulphur dioxide from the process fuel is absorbed by the alkaline product. Electrostatic precipitators at the plants do not significantly reduce the quantity of gaseous pollutants emitted. Emissions of sulphur dioxide and nitrogen dioxide are shown in the following table and were based on factors taken from AP-42.

Table: Annual Emissions: Cement Manufacturing Industry.
(tonnes)

Year	SO_2	NO_2
1981	63	868
1982	68	528

2.7 CLAY PRODUCTS MANUFACTURING

Emissions of sulphur dioxide and sulphuric acid mist have been sampled on a number of occasions at the only Manitoba plant in this industry sector. The kiln is gas fired and sulphur dioxide emissions from fuel consumption are negligible. Sulphur dioxide may however be emitted from bricks at high temperatures and an average of eleven tests taken over the years 1981-1983 indicates an average emission factor of 35.0 kg/hr (including H_2SO_4 as SO_2 equivalent). The NO_2 emissions were based on AP-42 and average production rates over the number of days of operation per year.

Table : Annual Emissions: Clay Products Manufacturing (tonnes)

Year	SO_2	NO_2
1981	176	8
1982	146	7

2.8 LIME MANUFACTURE

Oxides of sulphur and nitrogen are not given off in the process of converting limestone to lime per se but the fuel used in heating the rock to drive off carbon dioxide and water generates these pollutants as by-products. At the single industry in this sector a significant fraction of the sulphur oxides are retained in the rotary

kiln and a further reduction in emissions from the plant is achieved through the use of a wet scrubbing system. The quantities and sulphur content of the sub-bituminous coal and oil consumed by the company were available on a monthly basis. These factors were used in conjunction with emission factors supplied in the EPA emission factor report AP-42 to generate the annual emission figures following.

Table : Annual Emissions: Lime Manufacturing (tonnes)

Year	SO_2	NO_2
1981	7	125
1982	6	102

2.9 SECONDARY LEAD PROCESSING

Sulphur dioxide emissions from two lead smelters which have significant emissions have been measured in stack sampling surveys for SO_2 and H_2SO_4. "Equivalent SO_2" emissions from these sources have been averaged over a number of tests. The emission factors calculated using the stack sampling results were considerably higher than those suggested in AP-42. The explanation for this may relate to the high proportion of storage batteries used in the charge which contains residual quantities of sulphuric acid. An emission factor for NO_2 was not published in AP-42 and was thus taken to be negligible. Both blast and reverberatory furnaces were operational in producing SO_2 emissions from secondary lead smelters.

Table : Annual Emissions: Secondary Lead Smelters
(tonnes)

Year	SO_2	NO_2
1981	701	negl.
1982	424	negl.

2.10 FERTILIZER MANUFACTURING

Ammonia, urea, ammonium thiosulphate, and ammonium nitrate are manufactured by a single Manitoba fertilizer industry. Emission factors were taken from stack sampling results of the nitric acid plant and from emission factors appearing in a report on the fertilizer industry (Environment Canada 1983b).

Table: Annual Emissions: Fertilizer Manufacturing
(tonnes)

Year	SO_2	NO_2
1981	268	516
1982	342	308

3. EMISSIONS FROM FUEL COMBUSTION - STATIONARY SOURCES

3.1 POWER GENERATION BY UTILITIES

Three coal burning power utilities serving the public sector have been included in this estimate. The coal used was primarily Saskatchewan lignite and calculations based on 0.5% sulphur content by weight were used. Although a small amount of sulphur dioxide may be retained in the flyash, estimates made here assumed 100% conversion of sulphur to sulphur dioxide and no retention. Nitrogen dioxide emission factors were taken from AP-42. The three power utilities are located at Brandon (Manitoba Hydro), Selkirk (Manitoba Hydro), and Winnipeg (Winnipeg Hydro). Totals from these utilities for 1981 and 1982 are shown in the following table.

Table: Annual Emissions: Power Generation by Utilities (tonnes)

Year	SO_2	NO_2
1981	3,305	1,315
1982	2,177	863

3.2 INDUSTRIAL FUEL COMBUSTION

This segment involves estimates of emissions from the combustion of fuel in industrial establishments. Fuel types included are natural gas, heavy fuel oil, light fuel oil, stove oil and kerosene, liquified petroleum gas (LPG) and coal. The approach and

emission factors adopted in the 1978 Environment Canada Report "A Nationwide Inventory of Emissions of Air Contaminants" were used. Consumption was taken from a Statistics Canada publication. No LPG was listed for industrial fuel combustion and was thus not calculated. Where fuel was counted in with an industrial point source, the quantity of fuel was subtracted from the Statistics Canada reported value so that "double counting" did not occur. All coal useage was treated in the point source emissions.

Table: Annual Emissions: Industrial Fuel Combustion (tonnes)

Year	SO_2	NO_2
1981	731	1,242
1982	1,941	1,547

3.3 COMMERCIAL FUEL COMBUSTION

The approach used to calculate industrial fuel emissions was also applied to estimates of emissions from commercial fuel combustion. Emission factors were used as provided in the 1978 Environment Canada Report and accounted for regional differences in the sulphur content of various fuels (Environment Canada 1983a).

Table: Annual Emissions: Commercial Fuel Combustion (tonnes)

Year	SO_2	NO_2
1981	1,371	2,342
1982	2,365	3,679

3.4 RESIDENTIAL FUEL COMBUSTION

This segment includes emissions from the use of fuels used mainly for residential heating and air conditioning. The method followed that used by Environment Canada (Environment Canada 1983a).

Table: Annual Emissions: Commercial Fuel Combustion (tonnes)

Year	SO_2	NO_2
1981	829	1,124
1982	886	1,366

3.5 FUELWOOD COMBUSTION

This section includes emissions from the use of wood burned in furnaces, stoves and fireplaces. Again the method and emission factors used by Environment Canada (Environment Canada 1983a) were employed in making these estimates. Amounts of fuelwood consumed was taken from a Statistics Canada Report (Statistics Canada 1982b). Emission calculations appear in the following table.

Table: Annual Emissions: Fuelwood Combustion (tonnes)

Year	SO_2	NO_2
1981	negl.	168
1982	negl.	138

4. EMISSIONS FROM TRANSPORTATION SOURCES

4.1 GASOLINE POWERED MOTOR VEHICLES

The URTEI (Urban Road Transportation Emission Inventory) computer program was run by Environment Canada for the years 1981-1982 using data supplied by the Manitoba Highway Transport Board. This program calculated NO_2 based on vehicle registrations broken into various age, fuel use and weight categories. Actual emission data, collected for various fleets by Environment Canada, was applied in generating the factors used. Certain assumptions were made because the Manitoba vehicle registration categories did not match those of the model exactly.

Sulphur dioxide emissions from gasoline powered motor vehicles were based on emission factors and methods used by Environment Canada (Environment Canada 1982a). Buses were not included but were shown not to contribute significantly to the result.

Nitrogen dioxide emission for the years 1981 to 1982 are listed in the following table:

Table: Annual Emissions: Gasoline Powered Motor Vehicles (tonnes)

Year	SO_2	NO_2
1981	786	28,800
1982	793	27,600

4.2 RAILROADS

The quantity of diesel fuel used for railway transportation was taken from Statistics Canada Reports (Statistics Canada 1981b and Statistics Canada 1982c). Emission factors were provided by Environment Canada except that the sulphur dioxide factor was adjusted from a fuel sulphur content of 0.4% to 0.3% to generate an emission factor of 5.1 kg/10^3 L.

Table: Annual Emissions: Railroads (tonnes)

	SO_2	NO_2
1981	1,330	11,471
1982	1,194	10,300

4.3 MARINE

A Statistics Canada report was used to estimate the number of outboard motor boats in Manitoba in 1981 and 1982 (Statistics Canada 1981b and Statistics Canada 1982c). The power useage was then calculated using information obtained from an Environment Canada Report (Environment Canada 1983a). Two approaches were initially used employing emission factors related to fuel consumption and also to power consumed. The latter provided the higher value and since this was the approach adopted by Environment Canada it was reported. Only emissions from outboard motors were considered in this calculation.

Table: Annual Emissions: Marine Vessels
(tonnes)

Year	SO_2	NO_2
1981	8	9
1982	9	9

4.4 AIRCRAFT

Because the aircraft emissions are based on a relatively complex calculation and because emissions would not be expected to change considerably from 1980, the value determined by Environment Canada for 1980 was used for 1981 and 1982 (Environment Canada 1984b).

Table: Annual Emissions: Aircraft
(tonnes)

Year	SO_2	NO_2
1981	164	2,967
1982	164	2,967

4.5 INTERNAL COMBUSTION ENGINES (Off-Road Use)

Emissions of SO_2 and NO_2 calculated by Environment Canada for 1980 for this sector were employed as these emissions would not be expected to change significantly in 1981 and 1982 (Environment Canada 1984b).

Table: Annual Emissions: Internal Combustion Engines (Off-Road Use)
(tonnes)

Year	SO_2	NO_2
1981	160	3,430
1982	160	3,430

4.6 DIESEL POWERED ENGINES

Calculations of emissions from this source was taken from calculations performed by Environment Canada for 1980 (Environment Canada 1984b) and applied to both 1981 and 1982. These calculations include deisel oil used for construction equipment, agricultural equipment and other diesel engines. Consumption was based on a Statistics Canada Report. Buses were not included but were shown not to contribute signficantly to the result.

Table: Annual Emissions: Diesel Powered Engines
(tonnes)

Year	SO_2	NO_2
1981	2,230	18,440
1982	2,230	18,440

5. SOLID WASTE INCINERATION

The treatment of solid waste by burning may include emissions from municipal, industrial and commercial incinerators, sewage sludge incineration and wigwam burners. In Manitoba, the City of Winnipeg incinerator was the only municipal incinerator and this unit ceased operation April 30, 1979. Figures for industrial and commercial incineration and wigwam burners were calculated in the 1978 National Emissions Inventory (Environment Canada 1983a) and because of their small value and uncertain accuracy have been adopted for the 1981 and 1982 emission estimates.

Table: Annual Emissions: Solid Waste Incineration
(tonnes)
(based on 1978 figures)

	SO_2 (tonnes)	NO_2 (tonnes)
Industrial & Commercial Incineration	29	31
Wigwam Burners	2	15
Total (1981 & 1982)	31	46

6. COMBINED POINT AND AREA SOURCES

Combined point and area emissions have been calculated by Environment Canada for 1980 (Environment Canada 1984c) for a grid pattern covering Canada. Combined point and area sources of anthropogenic origin are listed for each 127 km x 127 km grid sector. The location of each grid is shown in Figure 1 and combined point and area emissions for each sector are shown in the following table. Grid sector location may be identified by the southwest grid co-ordinates.

Table: Annual Emissions: Combined Point and Area Sources (tonnes - 1980 Environment Canada data)

Grid Location	SO_2 (tonnes)	NO_2 (tonnes)
5137	169	867
5138	203	1,112
5139	42	200
5236	17	101
5237	2,583	6,221
5238	592	2,887
5239	272	1,950
5240	132	1,546
5241	480	1,286
5242	248,523	666
5336	484	2,230
5337	15,237	39,483
5338	189	1,106
5339	61	1,244
5340	14	770
5341	14	1,411
5342	48	1,453
5343	71	1,111
5436	226	2,247
5437	1,815	6,870
5438	137	1,244
5439	13	684
5440	2	487
5441	66	1,374
5442	19	1,421
5443	4	969
5444	6	42

5445	-	3
5446	-	2
5537	2	359
5538	11	756
5539	2	1,049
5540	1	1,351
5541	1	1,218
5542	214,677	2,665
5543	-	662
5544	4	15
5545	-	5
5546	-	2
5640	21	939
5641	21	1,271
5642	43	1,269
5644	1	8
5645	-	5
5740	-	132
5741	2	351
5742	1	156
5743	1	24
5744	35	211
Total	486,242	93,435

Area emissions include smaller point sources and distributed sources such as residential and industrial fuel combustion, transportation sources, structural fires etc. but does not include process emissions from major point sources which are treated separately. The Environment Canada total value shown above is slightly different from the Manitoba total because of some differences in calculational methods as well as differences between the above 1980 values and the 1981-82 values calculated in this report.

7. NATURAL EMISSIONS

7.1 SOILS, LAKES, MARINE, LIGHTNING

Two references generated by Environment Canada have been cited to provide estimates of natural emissions of sulphur and nitrogen compounds (Environment Canada 1980 and Environment Canada 1981). The contribution due to forest fires has not been included in totals appearing in these references because it has been calculated separately. The remaining natural sources (soil emissions, lake emissions etc.) should be reasonably stable from year to year. The emissions reported here are in terms of equivalent amounts of SO_2 and NO_2, (i.e. the values taken from the above reports for sulphur and nitrogen have been multiplied by the appropriate molecular weight ratio. It should be noted that ammonia and amines emissions were not included in the NO_2 estimate and that hydrogen sulphide and other reduced sulphur compounds were included in the SO_2 emissions estimate).

Table: Annual Emissions: Natural Sources
(tonnes)

SO_2	NO_2
102,124	473,439

7.2 FOREST FIRES

Information regarding the area of forest burned in forest fires was obtained from provincial government sources (Manitoba Dept. of Natural Resources. Gerry Mason, telephone conversation with the author, May 1984). Emission factors were taken from an Environment Canada report (Environment Canada 1983a). Sulphur dioxide emissions were taken to be negligible.

Table: Annual Emissions: Forest Fires (tonnes)

Year	SO_2	NO_2
1981	negl.	40,904
1982	negl.	1,592

8. REGULATED EMISSIONS

Some of the emission sources have had limits imposed on them by the Manitoba Clean Environment Commission. The limits are shown below for various sectors. In some cases the total allowable emission were estimated from conditions of the order which were not in terms of mass of pollutant but instead in terms of concentration, or mass per unit of production etc. The word 'partial' is used when all sources in a sector have not been regulated. The regulated values are arranged in order of maximum allowed to least allowed. Eight industries have Clean Environment Commission Orders covering sulphur dioxide and nitrogen dioxide.

Table: Annual Emissions: Regulated Limits

	Regulated Annual Emissions SO_2	NO_2
Primary Nickel Production	413,907	-
Primary Copper and Zinc Production	298,046	-
Petroleum Refining	14,600	-
Pulp and Paper Industry (PARTIAL)	3,063	-
Secondary Lead Smelting * (PARTIAL)	2,150	-
Sulphuric Acid Production	2,050	-
Fertilizer Manufacturing	275	340
Heating Power Production **	44	16

* The Clean Environment Commission Order covering this industry has been superceded by Federal Regulations.

** This estimate relates to a relatively small heating and power unit. Thermal power generation by utilities has not been included.

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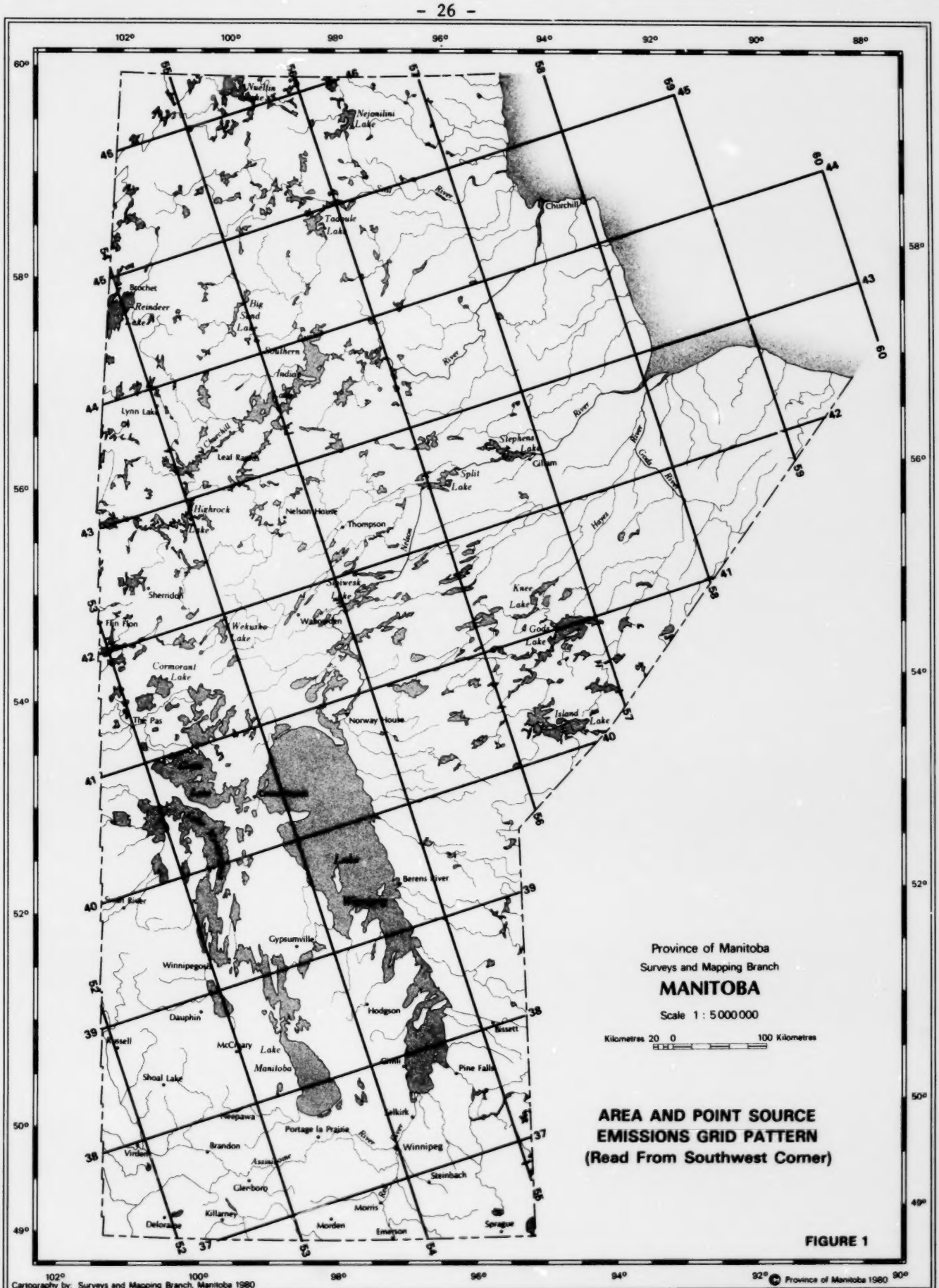
Province of Manitoba
Surveys and Mapping Branch
MANITOBA
Scale 1 : 5 000 000
Kilometres 20 0 100 Kilometres
AREA AND POINT SOURCE
EMISSIONS GRID PATTERN
(Read From Southwest Corner)
Cartography by: Surveys and Mapping Branch, Manitoba 1980
© Province of Manitoba 1980
Nejomilini Lake
Churchill
Tadoule Lake
Brochet
Reindeer Lake
Big Sand Lake
Southern Indian Lake
Lynn Lake
Leaf Rapids
Stephens Lake
Gillam
Split Lake
Highrock Lake
Nelson House
Thompson
Sherridon
Flin Flon
Wekusko Lake
Cormorant Lake
The Pas
Knee Lake
Gods Lake
Island Lake
Norway House
Berens River
Gypsumville
Winnipegosis
Dauphin
Hodgson
Russell
McCreary
Lake Manitoba
Shoal Lake
Grand Rapids
Pine Falls
Minnedosa
Portage la Prairie
Selkirk
Brandon
Virden
Winnipeg
Steinbach
Glenboro
Killarney
Morris
Deloraine
Morden
Emerson
Sprague

FIGURE 1